# High Load Transit Line Passenger Transmission and Productiveness Efficiencies

**Introduction**

- Measures describing productive performance of individual transit service or whole line are very useful in quantifying:
  - Resources' capabilities
  - Passengers' Quality of Service
- This paper extends productive performance measures to quantify:
  - Efficiency
  - Operating fashion
- These are demonstrated to be useful to transit operator in planning, design, operational activities

**Definitions and Propositions**

- *Transit work* is the product of transported objects and distance carried (p-km)
- *Passenger transmission* is the product of spaces utilized and vehicle speed (p-km/h)
- *Transit productiveness* is the work delivered over time along a line (p-km/h)
- *Ideal conditions* occurs where and when service operates at Maximum Scheduled Load and according to schedule
- *Passenger transmission efficiency* is the ratio of actual to ideal
- *Transit productiveness efficiency* is the ratio of actual to ideal
- *Passenger churn* the ratio between total boardings and total work performed during a time period (p/p-km)
- *Av. proportion line length traveled* is the ratio of average distance traveled by passenger and line length (%)

**Variation along Line**

- Passenger demand is spread out both over space and time
- This prevents offered capacity from being fully utilized throughout peak period
- Analyzing an entire line in terms of utilized work provides a picture of total transit performance during a time period

**High Passenger Load Conditions**

- Pass-ups occur where passengers are left behind, when a service departs under Maximum Scheduled Load
  - peak spreading
  - irregularities in stop dwell times between services
  - irregularities in services' travel times

| **Service *h* Transmission Efficiency along Line *L*** | |
|---|---|
| $\eta\{\Theta_{h,L}\} = \frac{T_{S,h,L} \sum_{i=1}^{n} P_{OB,h,i}\ s_i}{T_{h,n}\ P_{MSL,h} \sum_{i=1}^{n} s_i}$ | Scheduled journey time, actual journey time, Max. Scheduled Load, by segment: passengers on-board, segment length |
| **Service *h* Productiveness Efficiency during Time Period *Z*** | |
| $\eta\{\Pi_{h,Z}\} = \frac{\sum_{i=p}^{q} P_{OB,h,i}\ s_i}{P_{MSL,h} \sum_{i=p}^{q} s_i}$ | Max. Scheduled Load, by segment: passengers on-board, segment length |

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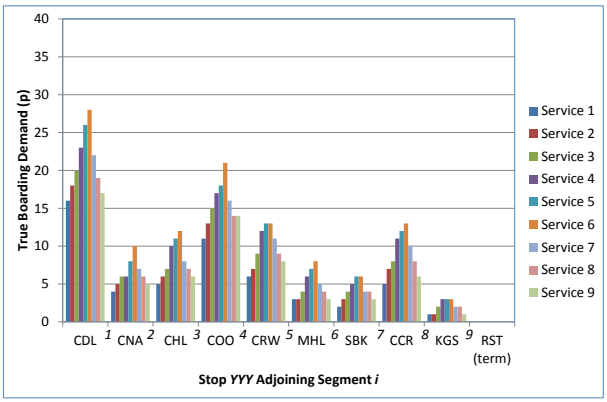
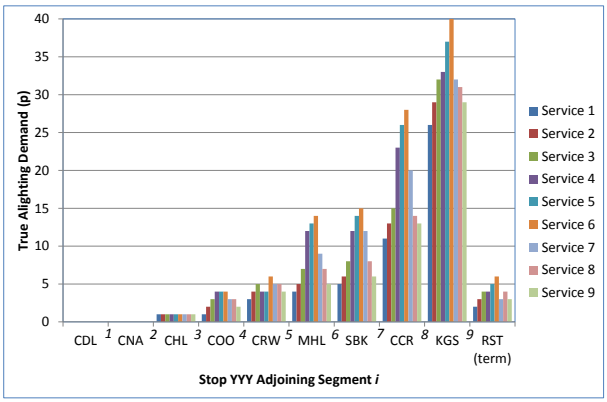
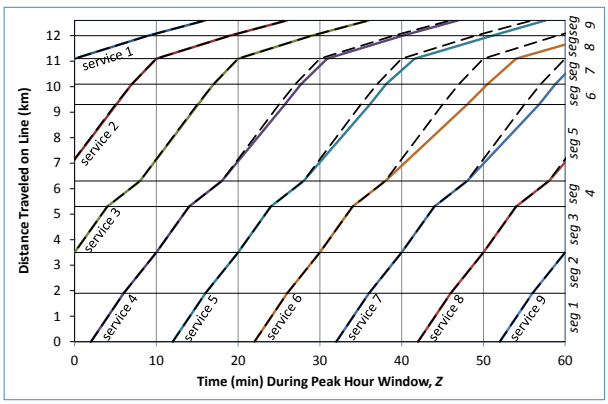
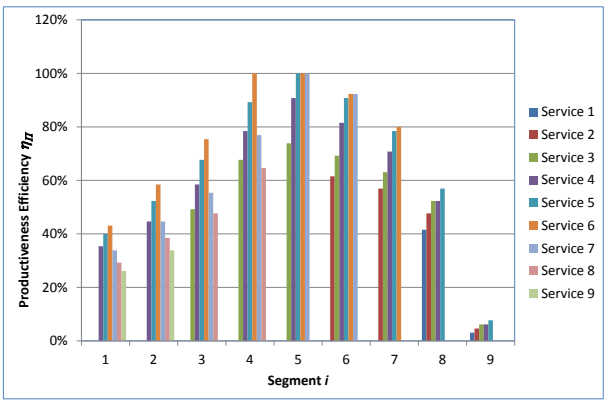


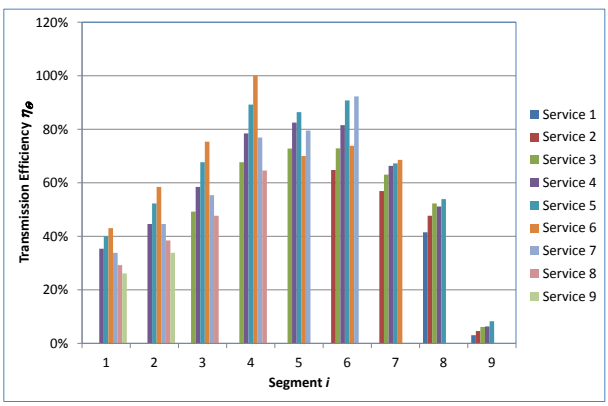

**Hypothetical Transit Line Peak Hour Example**

- Buses with 65p Max Scheduled Load (MSL)
- 10 min schedule frequency
- Pass-ups occurring where MSL is exceeded:
  - Service 5 on Segment 5
  - Service 6 on Segments 4, 5
  - Recovered by Service 7
- Path of each service:
  - Dashed represent the schedule
  - Solid colored are actual
  - e.g. service 6 falls behind schedule along segments 5 onwards




**Productiveness Efficiencies (Load Factors)**

- Overall line productiveness efficiency 61.6%
- Some 100% efficiencies are occurring
  - In this example corresponding to pass-ups, recoveries
  - These flag potential pass-up activity
  - Operator should investigate any segment where 2 or more successive services exhibit 100% values using field observations, driver logs, APC




**Passenger Transmission Efficiencies**

- Overall line transmission efficiency 59.6%
- Match productiveness on Segments 1 to 4
- Lower on Segment 5 for all service because the schedule is exceeded
- Higher on Segment 6 for Services 2 and 3 due to schedule recovery

**Differences in Overall Efficiencies**

- Where Productiveness > Transmission schedule is not being met by service/s
- Where Productiveness < Transmission service/s are running ahead of schedule

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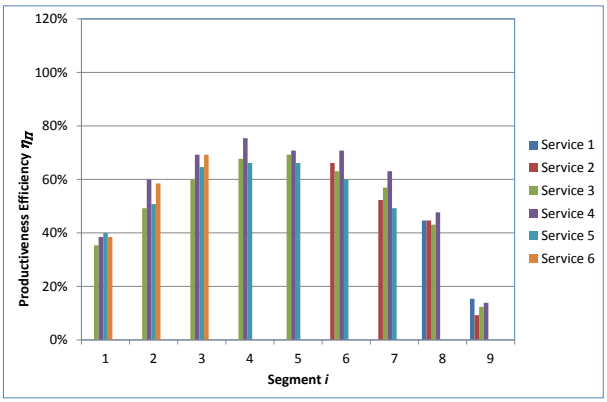


**Hypothetical Transit Line Daytime Hour Example**

- Buses 65p Max Scheduled Load
- 15 min schedule frequency
- No pass-ups
  - Reflected by no 100% productiveness efficiency values
- All services are running to schedule
  - Productiveness efficiencies (load factors) = transmission efficiencies
- Overall line productiveness efficiency 55.2%

| Comparator | Peak Hour | Daytime | Comment |
|---|---|---|---|
| Overall line productiveness | 2,808p-km/h | 1,665p-km/h | Less daytime demand for travel |
| Overall line prod'ness efficiency | 61.6% | 55.2% | Similar resource effectiveness |
| Av. proportion line length traveled | 40% | 25% | Shorter, mixed suburban daytime trips compared to commuter peak hour |

**Conclusions**

- 100% Productiveness Efficiency for successive services at a stop flags to Operator potential pass-up activity
- Differences between a line's Productiveness Efficiency and Transmission Efficiency profiles for a given time period flags to the Operator poor schedule adherence
- Insight into temporal variation in a line's operating fashion can be gained by comparing between different time periods (e.g. a.m. peak, daytime)
  - Productiveness Efficiency profiles
  - Average Proportion Line Length Traveled values
- Variation in a line's operating fashion can be used to target improvements in planning, design, operational activities such as
  - Stop spacing specification
  - Stop amenities provision
  - Passenger Quality of Service evaluation

**Future Research**

- Refine guidance to the Operator on potential pass-up activity through 100% Productiveness Efficiency flag
- Determine suitable Policy Productiveness Efficiency value or range relevant to Operator / system type
- Apply methodology to an actual bus line's operation
  - throughout a typical weekday
  - using APC data, field observations of pass-ups
  - Investigating variation in operating fashion using Average Proportion Line Length Traveled

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